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004 EPA Star Graduate Fellowship Conference
Next Generation Scientists—Next Opportunities

ilot Plant for CO_2 Capture using Aqueous Piperazine/Potassium Carbonate

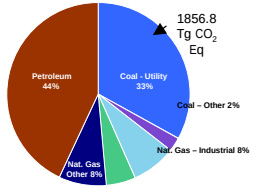
Overview

O_2 capture and sequestration technology for coal-fired wer plants is currently in the developmental stage. onomic evaluations with the current state of the art noethanolamine (MEA) solvent show that electricity costs l increase between 50-90%. Research is needed to velop solvents that have lower energy requirements for lvent regeneration, faster absorption rates, and less rrosion and packing with large contact areas and low essure drop. The focus of this research will be to monstrate a new solvent in a pilot-scale absorber/stripper stem and to optimize the packing selection process.

Environmental Issue

- 6% U.S. Energy from Fossil Fuel (2001)
- 1% Increase in U.S. CO_2 Emissions from Electricity Generation (1990 – 2001)
- Concern of Global Warming rom Greenhouse Gases
- Renewed Interest in CO_2 Capture and Sequestration

U.S. CO_2 Emissions by Type & Sector in 2001



From: Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 2001 (EPA 430-R-03-004)

Motivation

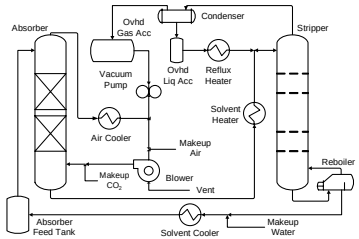
- New Solvent Developed by T. Cullinane (2002) - 2.5 m Piperazine / 2.5 m K_2CO_3
- CO_2 Absorption Rate 1 to 3 Times Faster than 30 wt% MEA and Heat of Absorption 10-25% Less than MEA
- Use 1.5-2.5 less Packing and Pressure Drop OR
- Operate with Closer Approach to CO_2 Saturation – Use 10-0% Less Energy than MEA Systems

Research Objectives

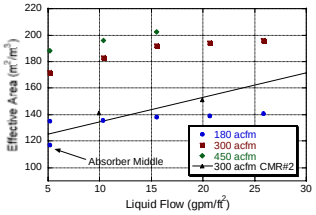
- Verify Cullinane Research on Large Scale
  - Temperature Effects on VLE, Kinetics and Diffusivity/Viscosity
- Determine Effective Area of K^+/PZ system
  - Measure $K_g a$ / Use Cullinane k_g'
  - Compare to Wilson/SRP Air-Water Data
  - Temperature, Viscosity, Surface Tension
- Validate Structured Packing as Alternative
- Target Application – Coal-Fired Power Plants

Absorber/Stripper Setup

- Pickle Research Center
- Column ID – 16.8 in
- Packed Height – 20 ft in 2 beds (10 ft each)
- P_{ABS} – 1 atm
- P_{STRP} – 0.2 to 2 atm
- Multi-use facility (distillation/extraction)



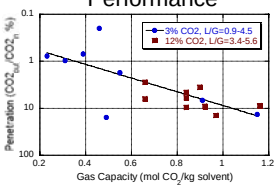
Flexipac 1Y Effective Area
Spec Area = 410 m^2/m^3, 0.1 N KOH



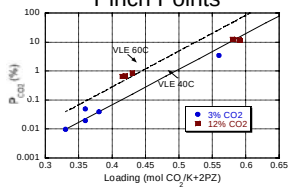
- Campaign 1 - Pilot Plant Setup & Troubleshooting and Characterize Absorber (Completed)
- Campaign 2 – Characterize Absorber & Stripper with Alternative Packing (10/04)
- Campaign 3 – MEA Baseline (2/05)
- Campaign 4 – Demonstrate Optimized Process based on absorber/stripper models (5/05)

Absorber Results

Performance

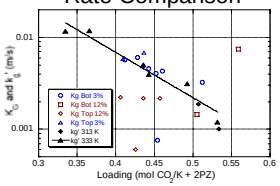


Pinch Points

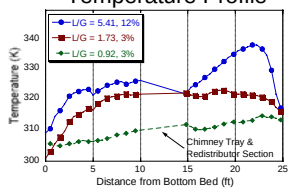


- Higher penetration = worse performance
  Lean Loading = 0.4-0.5(mol CO_2/(K+2PZ))
  3%CO2,L/G =0.9-4.5(kg/kg)
  12%CO2,L/G=3.4-5.6(kg/kg)

Rate Comparison



Temperature Profile



- K_G- Pilot Plant Absorber
  k_g' - Wetted wall column (Cullinane)

Impact/Conclusions

- Bench-Scale Rate Data Verified in Pilot Plant (16 Points)
- Penetration Increases with Capacity for 3 and 12% CO_2
- 12 Points in Pinch Regions
- >90% Removal with 20 ft packing - Flexipac 1Y 30% More Area Than CMR#2
- No Measurable Corrosion with 1000 ppm Vanadium
- Pilot plant data will be used to validate an absorber model that can be useful for designing commercial units

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